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Research Article

Epidemiological Pattern and Case Fatality Rate among COVID-19 Patients during First and Second Wave of Pandemic in Madhesh Province, Nepal

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ABSTRACT

Background & Objectives: Evaluating multi-wave patterns of COVID-19 infection, hospitalization, and mortality across spatial scales can inform public health strategies for future pandemics. However, there is limited understanding of these patterns in developing countries, including Nepal. This study aimed to analyze epidemiological patterns, fatality rates, and factors associated with severe outcomes during the first and second waves of COVID-19 in Madhesh Province, Nepal.

Materials and Methods: This retrospective cross-sectional study used provincial health records from Madhesh Province, covering April 9, 2020, to December 15, 2021, to analyze 37,551 positive COVID-19 cases and 1,037 deaths across two waves. The study examined changes in COVID-19-related deaths, with data on demographics, residence, isolation sites, treatment hospitals, care levels, and testing laboratories. The frequency and percentage of the variables were presented. The case fatality rate (CFR) for different categories were calculated. Additionally, the case fatality rate ratio (CFRR) for the first wave against second wave was obtained. Finally, case fatality risk ratios

with 95% confidence intervals were presented. A *p*-value of <0.05 was set as statistically significant.

Results: The case fatality rate (CFR) for COVID-19 was significantly higher in the second wave, especially among the elderly (≥47 years), and in institutional isolation (7.82%). Tertiary level care and private hospitals consistently showed higher CFRs. Furthermore, the multivariable analysis of risk ratios (RR) for COVID-19 case fatality in revealed that the 25–34 year age group had the highest RR (2.39). Similarly, males had a higher RR (1.42) than females, and institutional isolation had a substantially higher RR (93.33) compared to home isolation. Primary level care RR (28.11) and government hospitals RR (4.32) showed a higher risk. Place of residence also impacted the RR, with Sarlahi (7.68) having higher.

Conclusion: A significant increase in COVID-19 case fatality rates during the second wave, particularly among the elderly and those in institutional isolation. Higher mortality was observed in tertiary hospitals and among those who were tested in private laboratories, with substantial variations in risk ratios based on age, isolation type, and place of residence.

Keywords: COVID-19, case fatality rate, Madhesh Province.

INTRODUCTION

Despite the wide range of animal species from which coronaviruses have been isolated, bats are recognized as the primary natural reservoir, with four human coronaviruses—HKU1, NL63, 229E, and OC43—known to cause mild to moderate respiratory tract infections, including the common cold [1]. Coronaviruses such as SARS-CoV in 2002 and MERS-CoV in 2012 have been linked to nosocomial outbreaks and severe acute respiratory infections. Additionally, a novel coronavirus, later identified as SARS-CoV-2, unexpectedly emerged in Wuhan, China, towards the end of 2019, leading the World Health Organization to declare an international health emergency on January 31, 2020 [3]. The global spread of SARS-CoV-2 has occurred in waves, influenced by variant transmissibility, social distancing measures, healthcare access, and vaccination efforts [4,5].

Evaluating the epidemiological factors that shaped the multi-wave patterns of COVID-19 infection, hospitalization, and mortality across different spatial scales can enhance public health strategies for preventing future pandemics and saving lives. The COVID-19 pandemic has disproportionately affected many South Asian nations, including Nepal. Madhesh Province, one of Nepal's most populous regions, experienced significant impacts, with 20,635 cases in the second wave following 16,916 cases in the first. This study aimed to examine the epidemiological patterns, fatality rates, hospitalization rates, and factors associated with severe disease outcomes among patients during the first and second waves of COVID-19.

MATERIALS AND METHODS

Study design and setting: We conducted a retrospective cross-sectional study using provincial electronic health record data linked to COVID-19-related morbidity and mortality in Madhesh Province, Nepal. The data covered all COVID-19 cases and deaths from the first wave (April 9, 2020- to March 14, 2021) and the second wave (March 15, 2021 to December 15, 2021), provided by the Provincial Health Directorate of Madhesh Province. Madhesh Province, comprising eight districts (Parsa, Dhanusha, Saptari, Mahottari, Bara, Siraha, Rautahat, and Sarlahi), has a population of 6,114,600 (21% of Nepal's total population) with a density of

632.9/km^2, according to the 2021 National Population Census. Approximately 72% of this population resides in urban areas. During the COVID-19 pandemic, the provincial government established COVID-19-designated hospitals, expanded secondary-level hospitals, and upgraded existing facilities into COVID-19 clinics (for fever screening), as supported by the Ministry of Health, Government of Nepal. Locally available schools, community halls, and other buildings were used as isolation centers to closely monitor COVID-19 symptoms [8,9]. The province's COVID-19 response included case detection, confirmation via reverse transcriptase PCR (RT-PCR) tests, contact tracing, isolation, quarantine, and community-based initiatives. RT-PCR was used for case confirmation and contact tracing enabled officials to identify and test contacts within neighborhoods and families [10,11]. This study included all confirmed COVID-19 cases and deaths from the eight districts of Madhesh Province during study period.

Sampling and Sample Size: We compiled all confirmed COVID-19 cases and deaths in the study districts from April 9, 2020 to December 15, 2021 covering the first and second waves. The study sample included 37,551 positive cases and 1,037 deaths.

Data collection: We obtained data from provincial surveillance records managed by the Provincial Health Directorates, which oversee data collection and storage during health emergencies. The dataset, created using a Microsoft Excel-based reporting system, includes records of all COVID-19 cases and deaths from the first and second waves across eight districts of Madhesh Province, Nepal, with details on demographics, residence, isolation sites, treatment hospitals, care types, testing laboratories, and deaths.

Study variables and their measurement: In this study, we followed the Government of Nepal's definitions for the first and second waves of COVID-19 [12] dividing the pandemic into two phases based on provincial reports: the "first wave" (April 2020–March 2021) and the "second wave" (March 2021–December 2021). We assessed whether there was a significant change in COVID-19-related deaths between these waves. Independent variables from the provincial COVID-19 database included patient age categories (<25, 25-34, 35-46, ≥47 years), sex (male or female), and district of residence (Parsa, Dhanusha, Saptari, Mahottari, Bara, Siraha, Rauthat, Sarlahi). Isolation levels were classified as "home isolation" (schools, community halls, or other buildings) or "institutional isolation" (health facilities), with the latter further categorized into primary, secondary, and tertiary care levels. Hospital types and laboratory locations were classified as public or private.

Statistical analysis

The information was first retrieved from Microsoft Excel. Information was reviewed to ensure its completeness. Repeated record of patients was removed to avoid duplication. Participants with incomplete information were excluded from dataset. It was then transferred to the Statistical Package for Social Sciences (SPSS IBM, Version 21) for the analysis. The frequency and percentage of the variables were presented.

The case fatality rate (CFR) was computed separately for each wave by dividing the number of total deaths by total confirmed

COVID-19 cases [13]. To measure the severity or effectiveness of treatment, one crucial metric is the raw case fatality rate (CFR), which is calculated by dividing the reported number of COVID-19 deaths by the total number of cases [14]. The case fatality rate (CFR) for age groups, sex, place of residence (District), isolation level, hospital level of care, types of hospital for care and site at laboratory test performed were calculated as the total number of deaths divided by total cases diagnosed. Furthermore, the case fatality rate ratio (CFRR) for the first wave against second wave was obtained by dividing two CFR by each category [15].

For the multivariable analysis examining risk factors for mortality for all covariates identified and presented as case fatality risk ratios [16], along with their associated 95% confidence intervals (CI). A *p*-value of <0.05 was set as statistically significant. The epidemic curve was created through Excel to visualize monthly cases and deaths. Similarly, an alluvial diagram was created to depict the distribution and transitions of COVID-19 cases between the first and second waves and was prepared with the use of RAW graphs-2 software.

Ethical consideration: Ethical approval was granted by the Ethical Review Board of the Nepal Health Research Council (Reference number 496/2021P), and administrative approval was obtained from the Provincial Health Directorate of Madhesh Province (Reference number 31/077/089 dated 2078/04/13) to access de-identified data. Participants' confidentiality and anonymity were maintained throughout the data synthesis process.

RESULTS

The epidemic curve reveals that COVID-19 cases rose from Chaitra 2076 (March-April, 2020), peaked in Shrawan and Bhadra 2077 (July to September, 2020), and fell by Magh 2077 (January-February, 2021) during the first wave. Cases increased again from Falgun 2077 (February- March, 2021), peaked in Jeth 2078 (May-June 2021), and fell by Mansir 2078 (November-December, 2021) during the second wave, with fatality rates increasing in both waves as cases increased (Figure 1).

Table 1 presents COVID-19 case and death data for Madhesh Province during the first and second waves. The first wave had 16,916 cases and 239 deaths, while the second wave saw 20,635 cases and 798 deaths. The under-25 age group had low death rates (0.2% and 0.4%) with high recovery rates, whereas those aged 35-46 experienced death rates from 1.0% to 3.0%. Males were more prevalent in both waves (82.4% vs. 67.5%), and while females had slightly higher death rates in the first wave (1.6% vs. 1.4%), this reversed in the second wave (3.5% vs. 4.1%). In the first wave, Parsa had the highest number of cases (18.6%), and Siraha had the fewest (9.8%); in the second wave, Dhanusha led with 27.7% of cases, while Sarlahi had the least (5.3%). Institutional isolation was predominant in the first wave (99.4%) but decreased to 47.8% in the second wave, where home isolation showed higher mortality (4.3%) in the first wave and institutional isolation had higher mortality (7.8%) in the second wave. Primary and secondary level hospitals had higher recovery rates, whereas tertiary hospitals had higher death rates (50.7% vs. 74.1%). Public hospitals reported more cases (92.2% vs.

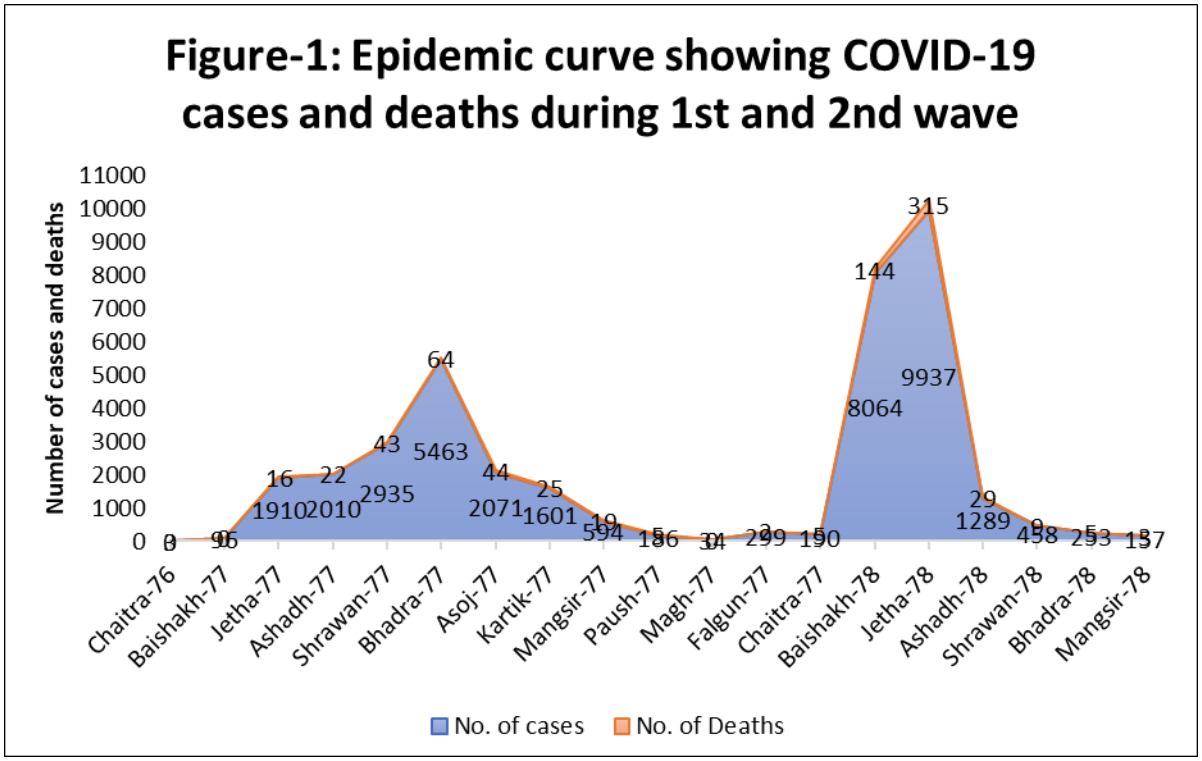

Figure 1. Epidemic curve showing distribution of all known cases during first (9th April 2020- 14th March, 2021) and second wave (15th March 2021- 15th December, 2021) of COVID-19 pandemic in Madhesh province

68.2%) but had lower mortality compared to private hospitals (7.9% vs. 31.8%). Laboratory testing was predominantly in public laboratories, with higher death rates among those tested in private laboratories (2.0% vs. 3.6%).

The case fatality rate (CFR) for COVID-19 patients in Madhesh Province varied significantly between the two waves across different demographics and conditions. The oldest age group (≥47 years) had consistently high CFRs in both waves (5.93% and 8.69%), while younger groups had lower rates. CFRs for both males and females increased in the second wave. Institutional isolation showed a much higher CFR in the second wave (7.82%) compared to the first (1.40%), whereas home isolation had higher CFRs in the first wave (4.26%) than in the second (0.25%). Tertiary level care had very high CFRs in both waves (50.69% and 74.07%), and private hospitals had significantly higher mortality rates (7.86% and 12.30%). CFRs from public and private labs were similar, with a slight increase in the second wave. The case fatality rate ratio (CFRR) analysis revealed that younger age groups had lower CFRRs, with the 25–34 age group showing the highest ratio (4.23). CFRRs were highest in Sarlahi and Rauthat (above 9) and lowest in home isolation (0.06) compared to institutional isolation (5.60). Tertiary level care had the lowest CFRR (1.46), while primary level care had the highest (41.04). Public hospitals had a higher CFRR (6.78) compared to private hospitals (1.57), and CFRRs from laboratory tests were relatively lower in both public (2.70) and private labs (2.75) (Table 2).

Table 1: Description of COVID-19 cases and death during first and second wave cohort in Madhesh province, Nepal

Characteristics	COVID 19 Wave-1			COVID-19 Wave-2		
	Overall Cases n=16916(%)	Deaths n=239(%)	Recovered n=16677(%)	Overall Cases n=20635(%)	Deaths n=798(%)	Recovered n=19837%)
Age quartiles						
<25 year	4861 (28.7)	11 (0.2)	4850 (99.8)	4005 (19.4)	16 (0.4)	3989 (99.6)
25-34 year	4874 (28.8)	13 (0.3)	4861 (99.7)	4788 (23.2)	54 (1.1)	4734 (98.9)
35-46 year	4010 (23.7)	39 (1.0)	3971 (99.0)	5149 (25.0)	153 (3.0)	4996 (97.0)
≥47 year	2951 (17.4)	175 (5.9)	2776 (94.1)	6590 (31.9)	573 (8.7)	6017 (91.3)
Missing	220 (1.4)	-	-	103 (0.5)	-	-
Sex						
Female	2981 (17.6)	49 (1.6)	2932 (98.4)	6714 (32.5)	232 (3.5)	6482 (96.5)
Male	13935 (82.4)	190 (1.4)	13745 (98.6)	13921 (67.5)	566 (4.1)	13355 (95.9)
District of Residence						
Parsa	3140 (18.6)	57 (1.8)	3083 (98.2)	3604 (17.5)	82 (2.3)	3522 (97.7)
Dhanusha	2625 (15.5)	29 (1.1)	2596 (98.9)	5704 (27.7)	111 (1.9)	5593 (98.1)
Saptari	1817 (10.6)	44 (2.4)	1773 (97.6)	1983 (9.6)	102 (5.1)	1881 (94.9)
Mahottari	1806 (10.7)	19 (1.1)	1787 (98.9)	2667 (12.9)	79 (3.0)	2588 (97.0)
Bara	1702 (10.1)	30 (1.8)	1672 (98.2)	2355 (11.4)	125 (5.3)	2230 (94.7)
Siraha	1652 (9.8)	29 (1.8)	1623 (98.2)	1722 (8.3)	119 (6.9)	1603 (93.1)
Rauthat	2117 (12.5)	13 (0.6)	2104 (99.4)	1505 (7.3)	88 (5.8)	1417 (94.2)
Sarlahi	2057 (12.2)	18 (0.9)	2039 (99.1)	1095 (5.3)	92 (8.4)	1003 (91.6)
Isolation level						
Home Isolation	94 (0.6)	4 (4.3)	90 (95.7)	10776 (52.2)	27 (0.3)	10749 (99.7)
Institutional	16822 (99.4)	235 (1.4)	16587 (98.6)	9859 (47.8)	771 (7.8)	9088 (92.2)
Hospital level of care*						
Primary level	13186 (78.4)	21 (0.2)	13165 (99.8)	459 (4.6)	30 (6.5)	429 (93.5)
Secondary level	3492 (20.7)	141 (4.0)	3351 (96.0)	9265 (93.8)	641 (6.9)	8624 (93.1)
Tertiary level	144 (0.9)	73 (50.7)	71 (49.3)	135 (1.6)	100 (74.1)	35 (25.9)
Types of Hospital for care*						
Public hospital	15499 (92.2)	131 (0.8)	15368 (99.2)	6722 (68.2)	385 (5.7)	6337 (94.3)
Private hospital	1323 (7.8)	104 (7.9)	1219 (92.1)	3137 (31.8)	386 (12.3)	2751 (87.7)
Laboratory test performed at						
Private Lab	2031 (12.0)	40(2.0)	1991 (98.0)	3070 (14.8)	163(5.3)	2907(94.7)
Public Lab	14606 (86.3)	189(1.3)	14417(98.7)	17554 (85.1)	624(3.6)	16930(96.4)
Missing	279 (1.7)	-	-	11 (0.1)		-
*Among institutionalized patients						

The multivariable analysis of the risk ratio (RR) for COVID-19 case fatality in Madhesh Province between the first and second waves shows significant variations based on socio-demographic and hospital-level factors. The oldest age group (over 47 years) had a lower RR (0.83) compared to the youngest group (under 25 years), with the highest RR (2.39) observed in the 25–34 year group. Males had a higher RR (1.42) than females. The place of residence impacted the RR, with Sarlahi (7.68), Rauthat (7.62), and Siraha (3.15) having higher ratios compared to Parsa. Institutional isolation had a much higher RR

Table 2: Case fatality rate and case fatality risk among COVID-19 patients during first and second wave cohort in Madhesh province, Nepal

Characteristics	COVID-19 Wave-1		COVID-19 Wave-2		Case Fatality Rate Ratio (Wave 1 vs Wave 2)	
	CFR	95%CI	CFR	95%CI	CFRR	95%CI
Age quartiles						
<25 year	0.23	0.09±0.36	0.40	0.25±0.55	1.77	1.36±2.17
25-34 year	0.27	0.12±0.41	1.13	0.98±1.27	4.23	3.66±4.80
35-46 year	0.97	0.67±1.28	2.97	2.71±3.24	3.06	2.52±3.59
≥47 year	5.93	5.08 ±6.78	8.69	8.13±9.26	1.47	1.03±1.90
Sex						
Female	1.64	1.19±2.10	3.46	3.15±3.76	2.10	1.59±2.62
Male	1.36	1.17±1.56	4.07	3.88±4.26	2.98	2.70±3.26
Place of Residence (District)						
Parsa	1.82	1.35±2.28	2.28	1.84±2.71	1.25	0.86±1.64
Dhanusha	1.10	0.70±1.50	1.95	1.68±2.22	1.76	1.26±2.26
Saptari	2.42	1.71±3.13	5.14	4.48±5.81	2.12	1.46±2.79
Mahottari	1.05	0.58±1.52	2.96	2.58±3.35	2.82	2.05±3.58
Bara	1.76	1.14±2.39	5.31	4.79±5.83	3.01	2.20±3.82
Siraha	1.76	1.12±2.39	6.91	6.31±7.51	3.94	3.00±4.87
Rauthat	0.61	0.28±0.95	5.85	5.46±6.23	9.52	8.04±11.00
Sarlahi	0.88	0.47±1.28	8.40	7.87±8.93	9.60	7.86±11.35
Isolation level						
Home Isolation	4.26	0.17±8.34	0.25	0.14±0.64	0.06	0.03±0.55
Institutional	1.40	1.22±1.57	7.82	7.60±8.04	5.60	5.14±6.05
Hospital level of care*						
Primary level	0.16	0.09±0.23	6.54	6.18±6.89	41.04	36.54±45.54
Secondary level	4.04	3.38±4.69	6.92	6.52±7.31	1.71	1.28±2.14
Tertiary level	50.69	42.53±58.86	74.07	67.96±80.19	1.46	0.56±3.49
Types of Hospital for care*						
Public hospital	0.85	0.70±0.99	5.73	5.51±5.94	6.78	6.18±7.38
Private hospital	7.86	6.41±9.31	12.30	11.39±13.22	1.57	0.90±2.23
Laboratory test performed at						
Private Lab	1.97	1.37±2.57	5.31	4.83±5.79	2.70	1.99±3.40
Public Lab	1.29	1.11±1.48	3.55	3.39±3.72	2.75	2.48±3.01

CFR=Case Fatality Rate; CFRR= Case Fatality Rate Ratio *Among institutionalized patients

(93.33) compared to home isolation. Primary level care had a significantly higher RR (28.11) than tertiary care. Government hospitals had a higher RR (4.32) compared to private hospitals. The site of laboratory tests showed minimal differences, with public laboratories having a slightly higher RR (1.02) than private laboratories (table 3).

An alluvial diagram illustrates the distribution and transitions of COVID-19 cases between the first and second waves, linking socio-demographic characteristics (age groups and gender), place of residence (district), types of isolation, and institutions for care to death or survival status (Figure-2).

Table 3: Multivariable analysis of case fatality risk ratio in relation to baseline demographic and hospital related characteristics among COVID-19 patients cohort in Madhesh province, Nepal during first and second wave

Characteristics	Risk Ratio	95% CI	*p*-value
Age quartiles			
<25 year	1.00	Ref.	-
25-34 year	2.39	1.96-2.82	<0.05
35-46 year	1.73	1.33-2.13	<0.05
≥47 year	0.83	0.50-1.16	>0.05
Sex			
Female	1.00	Ref.	-
Male	1.42	1.22-1.62	<0.05
Place of Residence (District)			
Parsa	1.00	Ref.	-
Dhanusha	1.41	0.96-1.86	>0.05
Saptari	1.70	1.11-2.29	<0.05
Mahottari	2.26	1.57-2.95	<0.05
Bara	2.41	1.68-3.14	<0.05
Siraha	3.15	2.31-3.99	<0.05
Rauthat	7.62	6.49-8.75	<0.05
Sarlahi	7.68	6.53-8.83	<0.05
Isolation level			
Home Isolation	1.00	Ref.	-
Institutional	93.33	92.95-93.71	<0.05
Hospital level of care*			
Tertiary level	1.00	Ref.	-
Secondary level	1.17	0.81-1.53	>0.05
Primary level	28.11	20.77-35.45	<0.05
Types of Hospital for care*			
Private hospital	1.00	Ref.	-
Government hospital	4.32	3.22-5.42	<0.05
Laboratory test performed at			
Private Laboratory	1.00	Ref.	-
Public Laboratory	1.02	0.86-1.18	>0.05

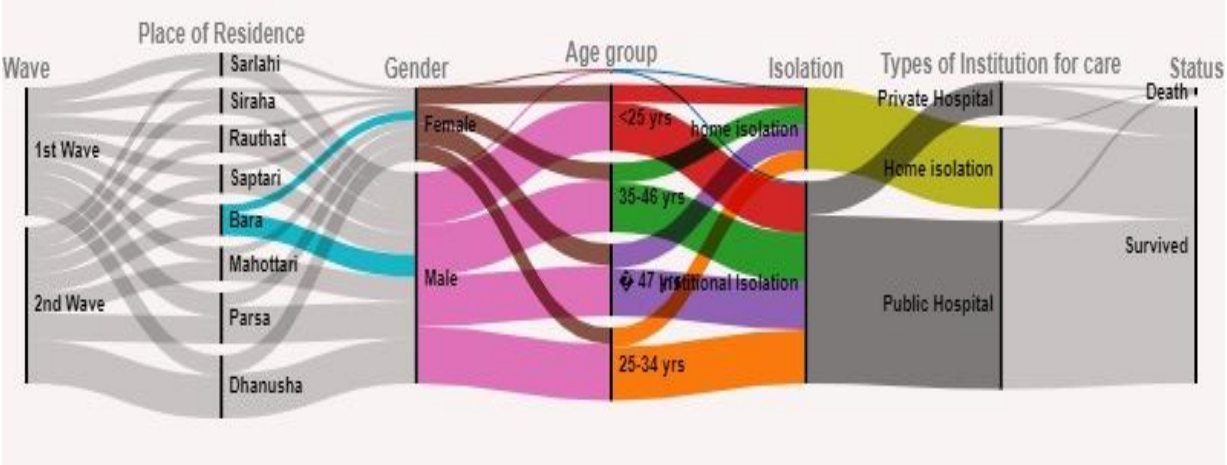

Figure 2: Alluvial diagram showing distribution and transitions of COVID-19 cases between first and second waves relating various characteristics to death or survival status

DISCUSSION

This study highlights a significant increase in COVID-19 case fatality rates during the second wave (16916 cases and 239 deaths in the first wave, Vs 20635 cases and 798 fatalities in the second wave), especially among the elderly and those in institutional isolation. The data reveals higher mortality rates in tertiary hospitals and private laboratories, with notable variations in risk ratios across different age groups, types of isolation, and places of residence.

Our study found that the first wave of COVID-19 cases peaked during August and September 2020, while the second wave reached its peak in May and June 2021. Both waves occurred during relatively warmer periods of the year; however, human coronaviruses generally exhibit a tendency to spread more prominently during the winter months [17]. Seasonal peaks in COVID-19 cases are influenced by factors such as the virus's enhanced survival in colder, drier conditions, increased indoor crowding during colder months, and potential impacts on immune response, which collectively facilitate higher transmission rates. In our study, higher COVID-19 case peaks during summer months may be attributed to increased travel, gatherings, and social interactions, which enhance virus transmission despite its general preference for colder conditions.

Several previous studies [18, 19, 20] reported that socio-demographic factors such as age, sex, place of residence impacted on occurrence of COVID-19 cases and fatalities similar to our study. We observed that the first COVID-19 wave primarily impacted younger age groups under 34 years, while the second wave, we observed a greater effect on individuals aged 47 and above. In a similar study in Nepal, the age groups most affected by the first and second COVID-19 waves were 60–79 years and 40–59 years [19]. The consistent impact on the male and elderly population across both waves in our study, and similarly reported in Maharashtra, India [20] and Nepal [19] indicates that older age groups and males were consistently more vulnerable to COVID-19 during both waves, highlighting the need for targeted public health interventions for these demographics. Our findings depicted that Parsa was the most affected during the first wave, while Dhanusha had the highest cases in the second wave of COVID-19 in Madhesh Province.

Institutional isolation dropped significantly in the second wave, yet mortality rates in institutional isolation were higher compared to the first wave, reflecting a similar trend of increasing death rates in subsequent waves as seen in other studies [21]. We found during the first wave, the majority of COVID-19 cases in Madhesh Province were admitted to primary level health care facilities (78.4%), while in the second wave, most were admitted to secondary level care (93.8%). Despite only 1.6% of patients being admitted to tertiary level care in the second wave, these facilities demonstrated a disproportionately high mortality rate of 74.1%, a trend consistent with findings from similar previous studies [21]. Public hospitals handled the majority of cases in both waves, though their share decreased in the second wave.

Our study revealed that majority of patients received treatment in primary care, although more patients in secondary care were seen in second wave. Despite fewer admissions to tertiary care hospitals in the second wave, these facilities had the highest mortality

rates, with 74.1% of patients dying, similar to the 75% death rate reported in a comparable tertiary care center in Nepal [19]. We assume that patients in tertiary care were likely more critically ill, leading to higher mortality. Furthermore, the consistently high CFR for those aged ≥47 years and increased CFR in institutional isolation during the second wave, coupled with higher mortality in private hospitals and tertiary care facilities, highlights a severe impact on older and critically ill patients, differing from trends observed in Nigeria [22, 23]. The differences in COVID-19 CFR between the findings could be attributable to variations in healthcare infrastructure, patient demographics, and healthcare practices between the regions.

We also observed that the COVID-19 case fatality rate ratios (CFRRs) varied significantly by age, gender, and geography, with the 25–34-year age group and men experiencing higher CFRRs compared to younger age groups and women, consistent with findings from other Nepalese studies [24] showing greater CFR in males and notable geographical variations in CFRRs. Specifically, residents of Sarlahi and Rauthat had higher CFRRs compared to those in Siraha and Bara, reflecting similar geographic differences reported in Bagmati Province of Nepal [19]. Institutional isolation showed a higher CFRR than home isolation, and primary level care centers had a higher CFRR than tertiary care centers, with public hospitals exhibiting higher CFRRs compared to private hospitals.

In our study, the multivariate analysis revealed higher risk ratios of COVID-19 CFR for age groups 25–34 and 35–46 compared to those under 25, with men at higher risk of COVID-19 CFR than women. Residents of Rauthat and Sarlahi faced over six times higher risk of COVID-19 CFR than those in Parsa, while primary level care had 28.11 times higher risk compared to tertiary care, and government hospital admissions were 4.32 times higher risk than private hospital admissions which suggests for target interventions for higher-risk age groups and men, focus resources on high-risk districts, enhance care quality in primary facilities, and standardize reporting practices to address disparities and improve outcomes.

The strengths of this study include the comprehensive use of provincial health records and the analysis of a large sample size, which provides robust insights into the epidemiological patterns of COVID-19. However, limitations include the retrospective nature of the data, which may affect the accuracy of reported outcomes, and potential inconsistencies in testing and reporting practices across different institutions.

CONCLUSION

The study highlights a significant increase in case fatality rates during the second wave, particularly affecting the elderly and individuals in institutional isolation. Increased mortality was observed more frequently in tertiary hospitals and among those who were tested in private laboratories, with significant variations in risk ratios related to age, type of isolation, and geographical location. To optimize COVID-19 management, it is crucial to enhance protocols for institutional isolation, address the elevated mortality rates in tertiary and private hospitals, implement targeted interventions for high-risk age groups and regions, and standardize testing and reporting practices across facilities.

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Supplementary information:

S1. Table: Months and date conversion from BS to AD

Months-Year [in BS]	**Months-Year [in AD]**
Chaitra-76	March-Apr:2020
Baisakh-77	Apr-May:2020
Jestha-77	May-Jun:2020
Ashadh-77	Jun-July:2-020
Shrawan-77	July-Aug-2020
Bhadra-77	Aug-Sept:2020
Ashoj-77	Sept-Oct:2020
Kartik-77	Oct-Nov:2020
Mangsir-77	Nov-Dec:2020
Paush-77	Dec:2020-Jan:2021
Magh-77	Jan-Feb:2021
Falgun-77	Feb-Mar:2021
Chaitra-77	Mar-Apr:2021
Baisakh-78	Apr-May:2021
Jestha-78	May-Jun:2021
Asadh-78	Jun-July:2021
Shrawan-78	July-Aug-2021
Bhadra-78	Aug-Sept:2021
Ashoj-78	Sept-Oct:2021
Kartik-78	Oct-Nov:2021
Mangsir-78	Nov-Dec:2021